APPENDIX Y

Report on Local and Regional Power Requirements and Generation Resources

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Marine Biological Issues for the Huntington Beach Desalination Project and Other Desalination Facilities

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Executive Summary

Studies conducted for the Huntington Beach Desalination Project include numerical modeling of the concentrated seawater discharge's dispersal and dilution to develop a strategy for minimizing its effect on the balanced indigenous community (BIC). This strategy focuses on preventing rather than lessening the potential effects of elevated salinity discharge through "in pipe" dilution of the concentrate before it is released, and the flow of the effluent into receiving waters having a high mixing potential due to the presence of wind- and tidally driven currents.

The strategy of optimizing site-specific features to maximize the dispersal and dilution of the discharge is in full agreement with recommendations found in the recent report on desalination by the U.S. National Academy of Sciences (NRC, 2008). It is also consistent with practices for concentrate discharge management currently in use by the 25 mgd desalination plant now operating at Tampa Bay, Florida. For the large capacity plants in Australia, for which the receiving waters do not in all cases have a sufficient mixing capacity to dilute the discharge, or in other cases where salinity equilibration must occur within a limited area, high-velocity diffuser nozzles are placed in series along the discharge line on the seabed to promote the mixing and rapid dilution of the seawater concentrate. In either case, whether the seawater concentrate is diluted by an array of high-velocity nozzles or by the combination of "in-pipe" dilution and a high mixing rate with the receiving water, its discharge will invariably result in the formation of a relatively small area of elevated salinity in the region around the discharge site.

Review of recently published information about the collective worldwide experience with the operation of large seawater desalination plants in Australia and at Tampa Bay

(US) indicates a positive track record for minimizing the potential effects of seawater concentrate discharge and this will be the objective at the Huntington Beach seawater desalination plant. Consistent with the examples reviewed in this report, the design of the Huntington Beach desalination project includes features that provide an additional margin of safety in terms of potential impacts of the discharge. These include using excess seawater flow to dilute the concentrate before it is discharged and use of a vertical discharge tower which, by directing the effluent upwards engages a larger portion of the water column to form a longer mixing path which thereby promotes mixing. Added to this is the high mixing potential of the turbulent coastal receiving water which features both wind and tidally driven currents. In addition to dissipating the plume in a relatively short distance, these currents also ensure that pelagic organisms that come in contact with the concentrated area of the plume can swim or drift through it in a relatively short time which will minimize its effect. Furthermore, the discharge itself enters an open area having a sand and mud bottom that is contiguous for many kilometers both up and down the coastline. This means that the species living near the discharge tower have extended distributions throughout Southern California. Another beneficial feature of the Huntington Beach project discharge location is that no endangered or threatened species or species of commercial significance occur in the discharge area which is not designated by the State of California to be an Area of Special Biological Significance.

An increased awareness of the environmental impact of discharging undiluted seawater concentrate into coastal waters has prompted monitoring studies of this effect in existing plants as well as increased attention to this issue in both the design and placement of desalination facilities. Prior experience shows that the discharge of concentrated seawater into shallow coastal areas that are not well ventilated by tidal or wind-driven circulation may cause elevation of coastal salinity and may affect the biota occurring in the discharge area. By contrast, in cases where the discharge is either diluted (as it is in the case of the Huntington Beach project) or lessened by mixing with the receiving water, the effects are either reduced or are not present at all. Such cases are discussed in the following sections of this report.

Agencies charged with regulating ocean discharge typically require project proponents to conduct salinity toxicity tests in order to set site-specific salinity thresholds for desalination plant discharges. Data have now been acquired worldwide and reviews of these, and related findings on salinity tolerance continue to confirm facts and conclusions contained in the studies conducted for the Huntington Beach project and affirmed by the National Academy of Sciences report, indicating that prolonged exposure to salinities at or below 40 parts per thousand (ppt) will not have an adverse effect to most marine species and thus will not significantly alter the integrity and function of the BIC. Environmental impacts for discharges with salinity of over 40 ppt are not necessarily harmful, but depend on site-specific conditions and especially on the marine flora and fauna inhabiting the discharge area.

Introduction

Considered in this report are key features of the Huntington Beach desalination facility's methodologies for handling chemicals used in the pretreatment of source water for RO, in the cleaning of the RO filters, and for disposing of the concentrated-seawater byproduct of desalination. With respect to the effects of the seawater concentrate on the balanced indigenous community (BIC) inhabiting the receiving waters, this report reviews and updates recent scientific data on salinity effects, reviews recent results of short-term and long-term salinity exposure toxicity testing, and details practices and procedures carried out at other large (≥25 mgd) desalination plants operating around the world.

I. Water Chemistry and RO

Much recent attention has been focused on the quantities of all the residual chemicals formed by processes such as pretreatment filter backwashes that are often added to and discharged with the seawater concentrate (Hoepner and Lattemann, 2002; Hashim and Hajjaj, 2005). While discharging backwash generated by sand media pretreatment is a common practice in the Middle East, in the US most existing desalination plants, including Tampa Bay, actually treat this backwash through sedimentation to remove the residual chemicals. The Huntington Beach desalination plant will use this treatment system for the filter backwash. In addition, to pretreatment of backwash water, desalination plants periodically (2-4 times per year) produce small volumes of spent cleaning solutions after washing the RO membranes. The general practice worldwide is to mix the untreated cleaning solutions with the RO concentrate for discharge into the ocean. Because over 95 % of the spent membrane chemicals are removed with the first clean-water flush of the membranes, the procedure at the Huntington Beach plant will be to direct the first flush into the sewer. Subsequent flushes, which contain trace levels of contaminants, will be added to the seawater concentrate and then mixed "in the outflow pipe" with the dilution water prior to discharge. Sludge, which contains conditioning chemicals used for seawater pretreatment will be dewatered and disposed to a sanitary landfill. The plans and procedures to be followed by the Huntington Beach desalination facility are thus consistent with best practices and with procedures followed by the two large desalination plants now operating in Australia (Perth, Gold Coast) and at Tampa Bay. As indicated above, these practices will lessen the discharge of contaminants and include on-site treatment processes to remove chemicals added for chemical conditioning of the source seawater prior to pretreatment.

Because the iron coagulant used for seawater pretreatment will be removed by sedimentation and dewatering, and will be disposed as a solid waste in a sanitary landfill, this treatment will reduce desalination plant discharge turbidity and remove over 99 % of the iron (a potential trigger for plankton blooms) from the discharge. Sludge generated from the re-mineralization of the desalinated water will be similarly treated. Chlorine present in the residual water will be neutralized by the addition of sodium bisulfite.

II. The National Academy of Sciences Report on Desalination

In 2006 the Committee for Advancing Desalination Technology of the U.S. National Academy of Sciences held workshops and conferences leading to the publication of the National Research Council Volume "*Desalination, A National Perspective*" (NRC 2008).

This report relied heavily on the studies conducted for the Huntington Beach desalination plant to develop its approaches and recommendations regarding the computational modeling of RO discharge movement and dissipation and determining its environmental effect. Two Poseidon consultants, Drs. S. Jenkins and J. Graham made a joint presentation to the committee in Irvine, CA in 2006 (Jenkins and Graham, 2006). Their presentation demonstrated how numerical modeling of the discharge plume could show its dispersal and dilution and that the resulting salinity contours could, by linkage with salinity tolerance data, allow conclusions about how different levels of salinity in the discharge would affect the BIC of the receiving waters.

Jenkins and Graham emphasized the added flexibility of using site-specific features to design the desalination discharge system is of critical importance and that for locations such as Huntington Beach, the concentrated discharge could be effectively managed to prevent any salinity impact on the BIC. The key site-specific features at Huntington Beach important for this are:

1) An excess water flow potential provided by HBGS' cooling water system which can be used to dilute the seawater concentrate
2) Reliance upon receiving water mixing to rapidly dilute the discharge to levels that are within the tolerable range of species (and by extension, most of the species comprising the receiving-water BIC).

It is clear that a critical part of desalination planning is site selection. As pointed out by Einav et al. (2002), NRC, (2008) and many other sources, an open ocean site, with a strong mixing potential (e.g., waves, coastal currents) is the primary factor in minimizing elevated-salinity discharge impacts. The studies conducted for the Huntington Beach desalination plant further emphasize that the three variables: RO capacity, "in-pipe" blending, and the mixing potential of the receiving water are key features affecting the salinity, dispersal, and dilution of the RO discharge and limiting the discharge plume to salinity levels that do not affect the structure and function of the BIC.

III. Field Assessments of the Environmental Effects of Concentrated Seawater Discharge: Desalination Facilities Located Worldwide

Background

This section provides an overview of relevant worldwide experience associated with the environmental effects of concentrated seawater discharges from other RO desalination plants similar to the Huntington Beach facility. This comparison shows that the technical challenges associated with minimizing the impacts of the concentrated seawater discharge from the Huntington Beach plant are less than those encountered at some of the other desalination facilities currently operating around the world. There are three primary reasons for this. First, the Huntington Beach desalination will use "in-pipe" dilution of the concentrated seawater before it is discharged into the ocean. The existing HBGS outfall is a vertical open pipe releasing the discharge upwards towards the ocean surface in mid-water column, approximately 15 ft (5 m) above the ocean bottom. As will be detailed below, instead of a single open pipe, some desalination plants discharge through a line equipped with a series of high velocity diffuser nozzles which maximize mixing. A comparative analysis of this technology and the single pipe discharge indicates that for the site-specific hydrodynamic conditions of the Huntington

Beach outfall, the use of a vertical discharge pipe is more environmentally beneficial (SEIR 2010, Appendix AA).

Hydrodynamic modeling additionally shows that, depending upon water-flow rate, "in-pipe" dilution of the seawater concentrate can reduce its salinity. Worldwide, some existing desalination plants such as the Tampa Bay Desalination Plant, the Sand City desalination plant in Northern California, and desalination plants in Spain (Fernández-Torquemada et. al., 2009) have "in-pipe" dilution (Fernández-Torquemada et. al., 2009) and others do not; the latter have discharge salinities ranging from 67 to 90 ppt and dilution occurs only when the discharge mixes with the receiving water (i.e., there is no in-pipe dilution of the seawater concentrate).

A second reason for a lower potential discharge salinity effect at Huntington Beach is the high-energy mixing capacity associated with the open-ocean coast receiving water, which has a continuous along-shore drift and both cyclic tidal and frequent wind-driven currents as well as periods of strong swell action (SEIR 2010, Appendix K). The siting of a desalination plant in such a location is exactly what is recommended by Einav et al. (2002) as ideal for maximizing the potential for the discharge to mix fully with the receiving water in order to lessen both the size of the salinity plume and the time and distance required for complete equilibration between the discharge and the receiving water. Comparisons with other desalination facilities indicates cases in which receiving-water mixing is inadequate for dilution of the concentrate and mixing enhancement by high-velocity diffuser nozzles ensures mixing and minimizes the elevated salinity footprint around the discharge. However, even with diffuser nozzles, an area of elevated salinity forms in the receiving waters around the discharge structure.

A third reason for a lower potential environmental impact of the Huntington Beach desalination plant discharge compared to the majority of other large desalination plants around the world is the nature of the marine habitat at Huntington Beach. In compliance with the AES HBGS discharge permit, over 25 years of biological monitoring data have been acquired by Marine Biological Consultants (MBC, Costa Mesa, CA; SEIR 2001, Appendix P) for the organisms living in the water column and on and in the benthic substrate around the Huntington Beach discharge tower. MBC has determined that the sandy and mud bottom habitat in the vicinity of the discharge tower has a continuous distribution extending many kilometers beyond the discharge area and its zone of initial dilution (ZID). This means that any potential salinity effect has less significance because it will be confined to an extremely small area within this contiguous habitat. Further, this receiving water habitat has a low biological diversity; the Pacific sand dollars, hermit crabs, and polychaete worms account for over 90% of the macrofaunal species occurring there. This area also contains no endangered or threatened species and is not designated by the State of California as an Area of Special Biological Significance (ASBS, a unique and sensitive marine ecosystem in need of preservation for future generations).

The Gold Coast and Perth (Australia) Desalination Plants

Australia is in the midst of an intense nationwide effort to construct large-capacity seawater desalination plants in Sydney, Perth, Adelaide, Melbourne and Brisbane (Alspach et al., 2009). In addition to functioning plants at Perth (34 mgd) and Gold Coast (33 mgd), the plants in the other three cities are at various stages of development; the 66 mgd plant at Sydney is now in the early stages of operation. These plants have capacities ranging from 36-108 mgd and the Melbourne plant (108 mgd) can be expanded to 143 mgd. In addition, private companies are also building another five desalination plants. One of these is a 75 mgd plant is now being planned for Whyalla, which is up inside the narrowest reaches of the Spencer Gulf, South Australia.

The Gold Coast Desalination Plant (35 mgd) – This plant is located in South East Queensland, Australia about 60 miles south of Brisbane in an area, like Huntington Beach, that is popular with tourists (Figure 1). The plant began operation in November 2008 and, when fully operational will supply 20% of the region's water requirement (Canneson et al., 2009). Several design features of this plant, its open intake, located 1.5 km offshore, 18 ft (6 m) over the seabed in 66 ft deep (22 m) water, and both its pretreatment system, and reverse osmosis filter train are almost identical to those of the Huntington Beach desalination plant. The Gold Coast plant is a stand-alone facility; it discharges a concentrate of 67 ppt into moderately well-ventilated receiving waters on the open ocean coast. To aid mixing nozzle diffusers located along the ocean bottom jet the concentrate upward into the water column to a height of approximately 30 ft (10 m, Figure 2).

Figure 1 –Gold Coast Seawater Desalination Plant

This configuration differs from Huntington Beach where a single vertical discharge pipe extending approximately 15 ft above the seabed discharges the water upward with sufficient momentum to drive it to the ocean surface. The ZID of the Gold Coast plant is 360 ft x 960 ft (120 m x 320 m), which is about 8 acres.

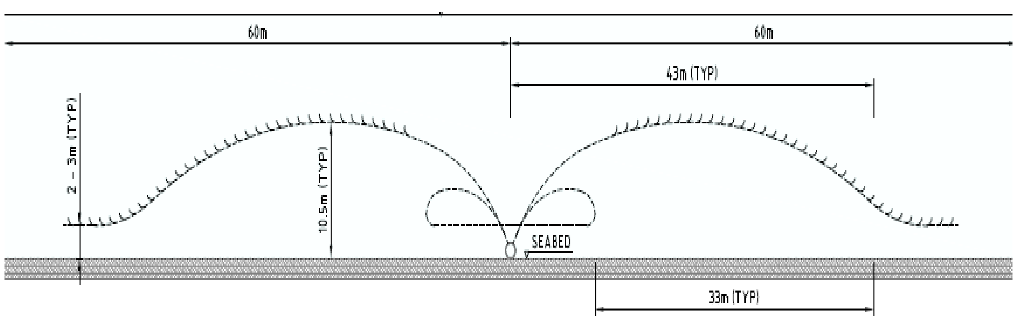

Figure 2 – Discharge of Gold Coast Seawater Desalination Plant

Figure 3 shows plant intake and outfall configurations as well as the biological monitoring sites located at different distances from the discharge field. The aquatic habitat at the Gold Coast Desalination Plant discharge is similar to that of the Huntington

Beach plant outfall area; it is a sandy bottom inhabited primarily by widely scattered tube anemones, sipunculid worms, sea stars, and burrowing sponges (Cannesson et al, 2009). Environmental monitoring of conditions and of the biota in the vicinity of the discharge began 18 months prior to the beginning of desalination operations and, to determine environmental impacts and verify the modeled salinity projections, monitoring has continued at four sites around the diffuser area; on each side of the zone and

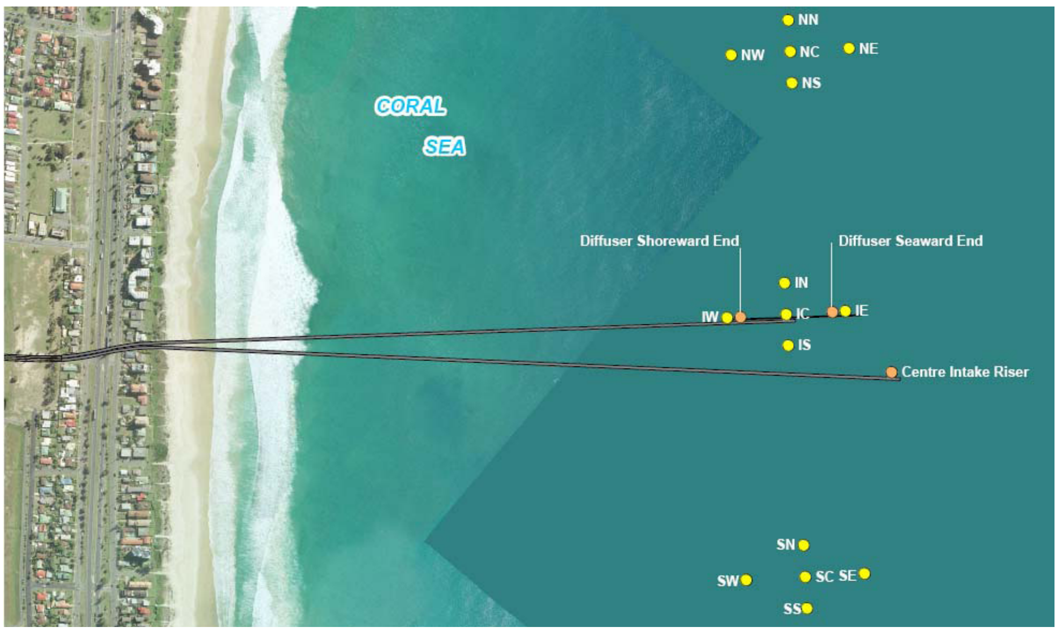

Figure 3 – Gold Coast Plant – Location of Discharge and Reference Monitoring Sites

at reference locations 1,500 ft (500 m) up- and down-coast from the zone. Neither water quality nor benthic infaunal abundance and diversity have changed significantly over this monitoring period, which means that the desalination operation has not had a significant impact on the marine organisms living near the discharge. The plant has now been in operation for over one year and monitoring to date continues to confirm that the Gold Coast plant discharge does not have a substantial impact on marine organisms.

The Perth Seawater Desalination Plant (38 mgd) – The Perth Plant (Figure 4) has been in continuous operation since early 2007 and it supplies over 17% of the drinking water for the area's population of over 1.6 million (Christie et al. 2009). The treatment facilities and waste streams generated by the Perth plant are very similar to those at Huntington Beach. Perth is also similar to the Gold Coast Plant in having a velocity cap-type open intake structure and both its granular media pretreatment filters and its reverse osmosis membrane system are like those planned for Huntington Beach. The plant's seawater intake is located 600 ft (200 m) from the shore at a depth of 18 ft (6 m) in

Figure 4 – 38 MGD Perth Seawater Desalination Plant

Cockburn Sound, which is a shallow, semi-enclosed water body having a limited ocean-water circulation and occasionally experiencing naturally occurring low oxygen levels in its deeper parts. This location makes the Perth plant's discharge area much more environmentally challenging than the Huntington Beach facility discharge which is located in a well-ventilated, open-water coastal habitat characterized by high oxygen content.

Because the receiving waters of the Perth desalination plant cannot adequately mix the 65 ppt discharge, it is dispersed through 40 diffuser nozzles positioned 16.5 ft (5 m) apart along two 300 ft (100 m) long sections of pipe located approximately 1,550 ft (500 m) offshore at a depth of 33 ft (10 m). The 8-inch (0.22 m) nozzles are set about 1.5 ft (0.5 m) over the seabed and they eject the concentrate upward at a 60-degree angle. This diffuser configuration forces the plume to rise about 28 ft (9 m) upward before sinking due to its elevated density. This results in a plume thickness at the edge of the mixing zone of 8.25 ft (2.5 m) and, in the absence of ambient cross-flow, 132 ft (40 m) laterally from the diffuser to the edge of the mixing zone (Figure 5). The ZID of Perth Desalination discharge is about 4.9 acres.

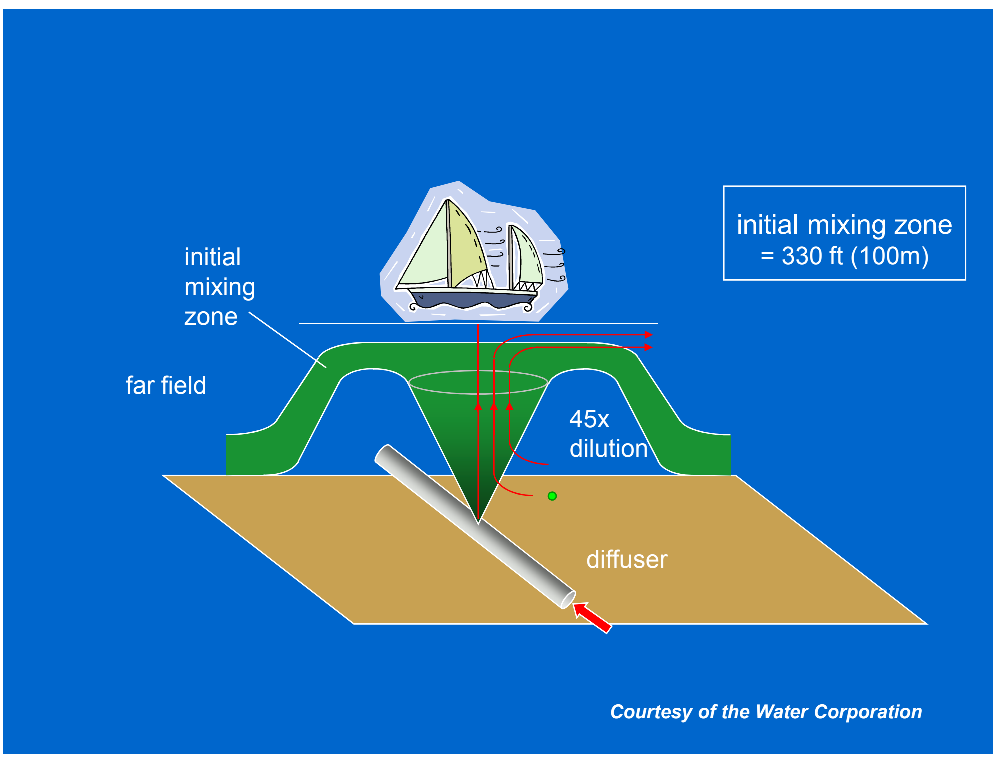

Figure 5 - Perth Desalination Plant Mixing Zone

Although it is highly diluted at the edge of the ZID, the discharge is still detectable further away and studies show it spreads laterally through the depth contours of Cockburn Sound and may persist as a semi-permanent feature located 6-12 ft above the sea bed. Field studies have also verified that the salinity discharge is sufficiently dispersed that it does not coalesce and form a deep, hypoxic layer that smothers the seabed (Okeley et al., 2007). Visual confirmation of the salinity plume dispersion was achieved by the use of the Rhodamine dye (Figure 6) in the discharge. After billowing to within about 10 ft (3 m) of the water surface, the dye-laden water fell toward to seabed

Figure 6- Perth Desalination Plant Discharge Diffuser – Rhodamine Dye Test

and slowly dispersed and was beyond visual detection within a distance of around 0.9 miles (1.5 kilometers), however, depending upon mainly wind-driven mixing and turnover in the receiving water, a high salinity plume can persist over the thermocline and extend some distance beyond the ZID (Okeley et al., 2007).

To determine the minimum dilution ratio needed at the edge of the ZID the following toxicity tests were carried out on marine species normally found in the waters around the discharge:

− 72 hour macro-algal germination assay using the brown kelp *Ecklonia radiata*,

− 48 hour mussel larval development using *Mytilis edulis*,

− 72 hour algal growth test using the unicellular algae *Isochrysis galbana*,

− 28 day copepod reproduction test using *Gladioferens imparipes*,

− 7 day larval fish growth test using a marine fish, the pink snapper, *Pagrus auratus*.

These toxicity tests show that concentrate dilution at the edge of the ZID ranges from 15.1 to achieve a 99% protection factor down to 9.2:1 for an 80% protection factor. These dilution ratios compare favorably to those modeled the discharge conditions of the Huntington Beach plant, where the minimum dilution ratio at the edge of the ZID is between 10:1 and 20:1.

In addition to toxicity testing, environmental surveys of the benthic macro-invertebrates living in the area were initiated before and have continued after plant operation began. A March 2006 baseline survey covered 77 sites to determine the spatial pattern of the benthic macrofaunal communities, while the repeat survey in 2008 covered 41 sites originally sampled in 2006 and 5 new reference sites. Comparisons of these two surveys indicate no changes in benthic communities that can be attributed to the desalination plant discharge.

Water-quality sampling completed in the discharge area has also shown no observable effect on ocean water quality except for a 1 ppt increase in deeper water salinity, which is well within the naturally occurring salinity variation. Figure 7 shows the concentrate conductivity (µS/cm) exiting the desalination plant over the period of January 2007 to September 2009. Using the relationship: Salinity = 0.78 x conductivity, Figure7 shows that the plant-discharge salinity varied between 56.2 ppt (72 µS/cm) and 64.5 ppt (88 µS/cm), which is higher than the salinity of the Huntington Beach discharge. Dissolved oxygen concentration of the discharge for the same period was between 7.6 and 11.0 mg/L, and was always higher than the minimum regulatory level of 5 mg/L. Similarly, concentrate pH was between 7.2 and 7.6, which was well within 10 % of the ambient ocean water pH, and also within the California Ocean Plan regulatory pH range of 6 to 9. Discharge turbidity for the same period (January 2007 to September 2009) was always less than 3 NTU, which is significantly lower than the California Ocean Plan limit of 75 NTU. Pictures of the discharge diffusers approximately one year

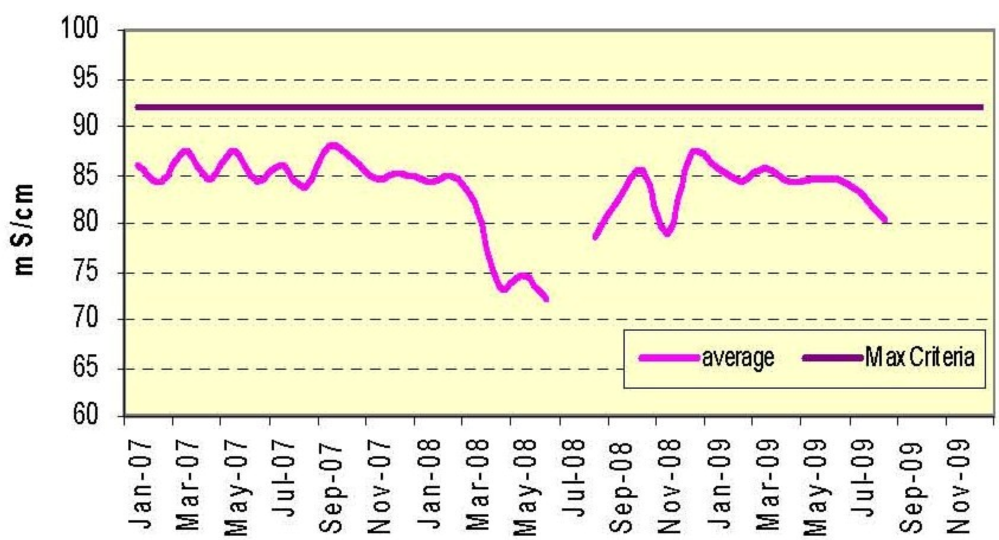

Figure 7 – Perth Desalination Plant – Concentrate Discharge Conductivity

after plant operations began (Figures 8 and 9) show that, despite the high salinity in the area (67 ppt), a diversity of benthic organisms are attached to and growing over the diffusers indicating that this mixing area supports marine life. Figure 9 is especially significant

Figure 8 – Perth Desalination Plant Diffuser with Swimming Fish

Figure 9 – Seahorse Inhabiting to Perth Desalination Plant Diffuser

as it shows that seahorses occur in the mixing zone, which has higher salinities than will occur within the ZID at Huntington Beach.

In summary, all studies and the continuous environmental monitoring completed at the Perth desalination plant, indicate that the concentrate discharge has negligible impact on the surrounding marine environment. This case study is especially relevant to the

Huntington Beach desalination project, because the Perth desalination plant has both a comparable ZID area and a similar dilution ratio at the edge of this zone.

The Tampa Bay Seawater Desalination Plant – 25 mgd. The Tampa Bay Seawater Desalination Facility produces up to 25 MGD of water and provides approximately 10% of the region's drinking water supply. Similar, to Huntington Beach, the Tampa plant is co-located with a power plant owned and operated by the Tampa Electric Company (TECO, Figure 10).

Figure 10 – Tampa Bay Seawater Desalination Plant

An average of 2,200 mgd of cooling water for the power plant is collected from Tampa Bay and a small portion of this water (44 mgd) is directed to the desalination plant for fresh water production. The desalination plant discharges 19 MGD of seawater concentrate (54 - 62 ppt) which is blended with the remainder of the power plant cooling water prior to discharging into Tampa Bay. Because of the large dilution volume of the cooling water, the blended discharge salinity is within 2 ppt of the ambient salinity.

Potential environmental impacts of this concentrate are monitored under a program implemented in 2002 and run by the Tampa Bay Water Authority independently of the desalination plant operator American Water-Acciona Agua (McConnell, 2009). Monitoring is based on a Plan of Study (POS) developed as required by special conditions of the NPDES Industrial Wastewater Discharge Permit issued by the Florida Department of Environmental Protection (FDEP). The plant permit requires additional supplemental sampling to be performed as part of Tampa Bay Water's hydro-biological monitoring program (HBMP). Water quality and benthic invertebrate monitoring includes fixed and random sites and is focused in areas most likely affected by the discharge including the power-plant discharge canal and areas of Hillsborough Bay and middle Tampa Bay near the mouth of the canal; a small embayment adjacent to the discharge canal is also monitored (Figure 11). The letters I and D on Figure 11 show intake and discharge canals, the letter A marks Apollo Bay –a shallow embayment in the vicinity of the discharge. Areas designated by yellow rectangles A, B and C are prime sampling sites, and areas D and NAB are supplemental. A control area considered representative of ambient background conditions was used for comparison. For fish and seagrass, data obtained in the area around the desalination plant by other government agencies were used to evaluate potential changes. In addition, the discharge permit also requires monitoring of chemical constituents to ensure that water quality in Tampa Bay is protected.

Monitoring for desalination facility effects began with baseline studies in April of 2002 and continued when the plant became operational (2003) and while it operated at varying production levels prior to being taken off-line for remediation in May 31, 2005.

The facility came back on-line on March 24, 2007. Evaluation of monitoring data from 2002-2008 showed that even during periods of maximum water production, changes in salinity were within or below expected values (less than 2 ppt increase over background) predicted by the hydrodynamic model developed during design. To date, there has been no indication that the facility has had an adverse impact on marine organisms or on the abundance or diversity of the area's biological resources. While benthic assemblages varied spatially in terms of dominant taxa, diversity, and community structure, the salinity did not vary among monitoring strata, and variables not related to discharge from the facility (i.e., temperature and substrate) explained the spatial heterogeneity observed. Patterns in fish community diversity in the vicinity of the facility were similar to those occurring elsewhere in Tampa Bay and no differences between operational and non-operational periods were observed (McConnell, 2009).

Figure 11 – Monitoring Areas of Tampa Bay Desalination Plant Discharge

The Desalination Plant Discharge Study at Antigua, West Indies. The study done in Antigua, West Indies, by scientists from the State of Florida, sought experimental data on the effect of the RO-concentrate discharge on an ecosystem in order to aid in predicting the effect of the desalination discharge from plants such as the one being built at that time in Tampa (Blake et al., 1996; Hammond et al., 1998). The Antigua study entailed multi-level experimental assessment of an RO discharge on corals and other organisms living in a tropical reef lagoon. Observations were made before and 6 months following the introduction of the undiluted (57 ppt) discharge from a small (1.8 mgd) RO plant. For the experiment the plant's discharge, which had been onto the beach at the edge of the lagoon was piped approximately 300 ft (100 m) to the lagoon's center where it exited vertically through a notched opening cut into the upper wall of the pipe. At this site the discharge was rapidly diluted (between 45 and 50 ppt at 1 m distance). Environmental monitoring, done before and after the discharge began, occurred along 6 radial transects extending from the discharge-pipe opening. Examined were the abundance, diversity, and health condition of organisms occurring along each transect. The results show that 6 months after the desalination discharge began in the center of the lagoon there were no detectible effects on the density, biomass, diversity, or health status of organisms living in the area, which included benthic microalgae and foraminifera and various macrofauna (polychaetes, oligochaetes, bivalves, gastropods, fish, anemones, worms, sea stars, corals).

V. Summary and Conclusions

A comparison of the operational methodologies for managing the discharge from large capacity ($\geq$25 mgd) seawater desalination plants in the US and Australia shows a basic similarity in their operations to that of Huntington Beach plant, which has several design features and other advantages that provide an extra margin of safety in terms of potential environmental impacts of the discharge. These include using additional seawater flow to dilute the concentrate before it is discharged into the ocean and the use of a vertical discharge tower which, by adding momentum to the effluent, increases mixing. An important feature also aiding in dilution and dispersal of the plume is the high mixing potential of the turbulent coastal receiving water, which features both wind and tidally driven currents. In addition to dissipating the plume in a relatively short distance, these currents ensure that pelagic organisms that come in contact with the concentrated area of the plume can swim or drift through it in a relatively short time which will minimize its effect. Further, the discharge itself is located in an open area having a sand and mud bottom that remains contiguous for many kilometers both up and down the coastline. This means that the species living near the discharge tower have extended distributions throughout Southern California. Finally, no endangered or threatened species occur in the discharge area which is not designated by the State of California as an Area of Special Biological Significance.

An increased awareness of the environmental impact of discharging the undiluted seawater concentrate byproduct of desalination into coastal waters has prompted environmental studies of this effect in existing plants as well as increased attention to this issue in both the design and siting of new plants and plants now in the planning stage. In new and planned plants, dilution and mixing by diffusers or the strategic placement of the discharge are standard procedures. For several plants in operation, documentation now exists for the damaging effects on the BIC resulting from discharging an undiluted seawater concentrate into shallow coastal areas that are not well ventilated by tidal or wind-driven circulation. Alternatively, case studies document that increasing the dilution of the discharge stream and/or extending the discharge pipe further off shore result in minimal salinity effects for the coastal BIC.

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